APPARATUS AND METHOD FOR MAINTAINING CONTROLLED ORIENTATION OF A ROLLER LIFTER FOLLOWER USED IN CONJUNCTION WITH A VARIABLE PHASED LIFTER

CROSS REFERENCE TO RELATED APPLICATION

This application is related to a co-pending patent application serial number 10/266,335 titled "APPARATUS AND METHOD FOR MAINTAINING CONTROLLED ORIENTATION OF A ROLLER LIFTER FOLLOWER USED IN CONJUNCTION WITH A VARIABLE PHASED VALVE LIFTER", and filed on October 8, 2002, now allowed, which is owned by the same assignee of this invention.

FIELD OF THE INVENTION

This invention relates to an internal combustion engine using poppet type valves to direct gases into and out of one or more cylinders or cam operated fuel injection units to inject fuel into one or more cylinders. More particularly, the orientation of a roller lifter follower in a pushrod operated engine is to be kept constant during rotation of a rotatable element to alter the phasing of the valves or injectors in the engine.

BACKGROUND OF THE INVENTION

A description of a phasing system for roller lifter followers on a camshaft is given by Riley in U.S. Patent Number 6,155,216, which is hereby incorporated by reference for all that is taught and disclosed therein.

As the rotatable element, such as an eccentric sleeve, is rotated to phase the roller lifter follower (hereinafter simply "roller lifter"), the roller lifter orientation must be controlled to allow the roller to follow the cam lobe on the camshaft. In fixed timing systems a simple pin or plate is usually sufficient to prevent the roller lifter from rotating around its longitudinal axis during operation. The arcuate path of the phased roller lifter requires an extra degree of freedom of movement. Therefore additional measures must be taken in order to maintain controlled orientation of the roller lifter.

SUMMARY OF THE INVENTION

The present invention describes a simple system for providing controlled orientation of a roller lifter in a pushrod engine using a phasing device to change the point of contact of the roller lifter on the cam. This system is applicable to single or multiple roller lifters. It also applies to roller lifters that may have curved surfaces for contacting the cam, but may not have rollers.

Roller lifters usually have either one or more flat surfaces machined into the outer body of the roller lifter. With the phasing mechanism described in U.S. Patent Number 6,155,216, the arcuate motion of the roller lifter during phasing would result in excessive clearance at most positions if a fixed anti-rotation mechanism were attempted, and misalignment between cam and roller lifter could result. In the present invention the roller lifter is allowed to move along a constraining face of a constraining mechanism, and the constraining mechanism is allowed to move freely in a direction substantially parallel to a line perpendicular to the flat surface machined onto the roller lifter. As the roller lifter moves through its arcuate path, the flat surface(s) of the roller lifter will slide across the constraining face(s) of the constraining mechanism.

An alternative embodiment of this anti-rotation approach is to have one or more locating pins extending from the side of the lifter, perpendicular to the roller lifter longitudinal axis. These locating pins would engage slots in a constraining mechanism and the constraining mechanism would be free to move in a direction substantially perpendicular to both the longitudinal axis of the roller lifter and the axis of the locating pins.

Another alternative embodiment of this anti-rotation approach is to machine one or more slots into the body of the roller lifter parallel to the longitudinal axis of the lifter. Engaging pins may be inserted into these slots, the engaging pins being attached to a constraining mechanism that

may move substantially perpendicular to the engaging pins and the longitudinal axis of the lifter.

Another alternative embodiment of this anti-rotation approach is a one-sided spring-like deformable constraining mechanism that pushes against the flat surface of a roller lifter. The constraining mechanism moves in one direction only while allowing movement of the roller lifter in the same direction as the constraining mechanism and in a direction substantially perpendicular to this direction.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows the prior art of how the geometry of rotation of an eccentric sleeve achieves transverse travel of a roller lifter on a cam lobe of a camshaft.

FIG. 2 shows an isometric view of one roller lifter with substantially parallel flat surfaces with one yoke-like constraining mechanism with two sides and stationary slots into which the constraining mechanism slides of the present invention.

FIG. 3A shows the objects in **FIG. 2** viewed from above, looking down the longitudinal axis of the roller lifter, where the roller lifter is shown in a position near one extreme of travel.

FIG. 3B shows the same view as **FIG. 3A**, but with the roller lifter now in a centered position.

FIG. 3C shows the same view as **FIG. 3B**, but with the roller lifter moved near to the other extreme of travel.

FIG. 4 shows an isometric view of a roller lifter and a two-sided yoke-like constraining mechanism with the location of the flat surfaces on the roller lifter located essentially perpendicular to their position in **FIG. 2**, where the direction of movement of the constraining mechanism is also substantially perpendicular.

FIG. 5 shows an isometric view of multiple lifters with a common two-sided yoke-like constraining mechanism of the present invention.

FIG. 6 shows an isometric view of a single roller lifter with a one-sided yoke-like constraining mechanism of the present invention.

FIG. 7 shows an isometric view of a single roller lifter with locating pins and a two-sided, slotted yoke-like constraining mechanism of the present invention.

FIG. 8 shows an isometric view of a single roller lifter with grooves in the roller lifter for orientation and a yoke-like constraining mechanism with engaging pins of the present invention.

FIG. 9 shows an isometric view of an alternative single-sided biasing mechanism that does not require slidably engaging slots.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the Figures, in which like reference numerals refer to like components thereof, **FIG. 1** shows the prior art of how the geometry of rotation of an eccentric sleeve achieves transverse travel of a roller lifter on a cam lobe of a camshaft. Referring now to **FIG. 1**, the geometry of an eccentric sleeve, in a view from the top of the roller lifter along the longitudinal axis of the roller lifter is shown. Circle **1** is the outside edge of the eccentric sleeve, with center **1a**, and circle **2** is the inside edge of the eccentric sleeve, with center **2a**, offset from the center **1a** of the eccentric sleeve. Circle **3** represents the path of the center of the offset as the eccentric sleeve is rotated. Circle **4** with center **4a** shows the position of the offset when the eccentric sleeve is rotated by some angle, here approximately 60° clockwise, around center **1a**. Similarly, circle **5** with center **5a** shows the position of the offset when rotated the same amount, approximately 60°, in the opposite direction around center **1a**. Line **6**, between the centers **4a** and **5a** of circles **4** and **5** respectively, shows the distance that the center of the roller **11** moves transverse to the axis of the camshaft **9a**, shown as arrow **7**. Line **8**, perpendicular to line **6**, is the farthermost distance to circle **3**. Circle **2** corresponds to the outer location of a roller

lifter that would make contact with cam lobe **9**. Line **8** represents the maximum fore-and-aft movement of the roller lifter along the axial direction of camshaft **9a**, parallel to arrow **7**.

Figure **2** shows an isometric view of one roller lifter with substantially parallel flat surfaces with one yoke-like constraining mechanism with two sides and stationary slots into which the constraining mechanism slides of the present invention. Referring now to **FIG. 2**, an isometric view of a single roller lifter **10**, with roller **11** and flat surfaces **12** which are substantially parallel to each other, engaged by constraining mechanism **13** is shown. Constraining mechanism **13** is constrained by one or more stationary blocks **14**, which are attached to the engine in any number of ways known in the art. Stationary blocks **14** have slots **14a** which receive end members **13a** of constraining mechanism **13**. This allows fore-and-aft movement only of constraining mechanism **13**, represented by arrow **25**, when actuated by movement of roller lifter **10**. Roller lifter **10** may also move within the constraints of constraining mechanism **13** substantially perpendicular to arrow **25**, represented by arrow **26**, through the interaction of parallel flat surfaces **12** with interior members **13b**, which are also substantially parallel to each other, of constraining mechanism **13**. Allowable movement in the two substantially perpendicular directions enables the arcuate travel path of roller lifter **10** as shown in **FIG. 1**. Roller lifter **10** also moves axially up-and-down along its longitudinal axis **27** as it engages with the cam (not shown). Thus, one skilled in the art will recognize that roller lifter **10** is prevented from rotating about its longitudinal axis **27** as it moves in arcuate fashion in cooperation with constraining mechanism **13**.

For simplicity one stationary block **14** is omitted from this view. Having all four stationary blocks **14** provides more constraint than is absolutely necessary. Only one stationary block **14** is necessary to provide a minimum amount of constraint for roller lifter **10**.

Various methods may be employed to ensure that constraining mechanism **13** remains operatively engaged within slots **14a** of stationary blocks **14** which are well known in the art. Though slots **14a** are shown as open channels in stationary blocks **14,** slots **14a** may also be fully contained within stationary blocks **14** in a hole-like fashion. In addition, though the end members **13a** and interior members **13b** of constraining mechanism **13** are shown as being square or rectangular in cross section, some or all of end members **13a** and interior members **13b** of constraining mechanism **13** may also be round in cross section or some other shape, or a combination of round, square, rectangular, or some other shape.

One skilled in the art will recognize that interior members **13b** that mate to flat surfaces **12** must be substantially parallel to each other. Failure to be substantially parallel would cause either wedging of the lifter, or excess slop when the lifter moved in the direction indicated by arrow **26** along interior members **13b**. On the other hand, the directions of movement indicated by arrows **25** and **26** need not be substantially perpendicular to each other. As long as the movement of constraining mechanism **13** allows the orientation of roller lifter **10** to be maintained, perpendicularity of movement is not required. The limit to the lack of perpendicularity is that the movement of constraining mechanism **13** in the direction indicated by arrow **25** cannot be oriented too close to parallel to the direction of movement of roller lifter **10** along interior members **13b** indicated by arrow **26** such that roller lifter **10** is constrained from moving through its eccentrically prescribed arc. A range from between 90° to about 30° between the orientation of the directions of movement indicated by arrows **25** and **26** should enable roller lifter **10** to move through its eccentrically prescribed arc without constraint while still being prevented from rotating about its longitudinal axis. An orientation below 30° may begin to impinge on the unconstrained eccentric movement of roller lifter **10**, and would not be desirable.

Figure **3A** shows the objects in **FIG. 2** viewed from above, looking down the longitudinal axis of the roller lifter, where the roller lifter is shown in a position near one extreme of travel. Referring now to **FIG. 3A**, the eccentric sleeve (not shown) is rotated approximately 60° counterclockwise from a centered position, displacing roller lifter **10**, whose center position is shown as center **10a**. The center of the roller lifter **10** will follow the arc on which center **10a** lies as the eccentric sleeve is rotated. This eccentric sleeve rotation results in phasing of the roller **11** (not shown) on cam lobe **9** differently from the centered position. Two end members **13a** of constraining mechanism **13** have moved into slots **14a** of stationary blocks **14** at the top of the diagram, and the other two end members **13a** have moved out of slots **14a** of stationary blocks **14** at the bottom of the diagram. Flat surfaces **12** on the roller lifter **10** (appearing as edges in this view) maintain the orientation of roller **11** on roller lifter **10** with cam lobe **9**.

Figure **3B** shows the same view as **FIG. 3A**, but with the roller lifter now in a centered position. Referring now to **FIG. 3B**, the eccentric sleeve (not shown) is in approximately its centered position, approximately 60° clockwise from its position in **FIG. 3A**. The position of the center of roller lifter **10** is center **10b**.

Figure **3C** shows the same view as **FIG. 3B**, but with the roller lifter moved near to the other extreme of travel. Referring now to **FIG. 3C**, the eccentric sleeve (not shown) is rotated approximately a further 60° clockwise from the centered position shown in **FIG. 3B**. The movement of constraining mechanism **13** towards the bottom of the diagram is obvious. The position of the center of roller lifter **10** is shown as center **10c**.

Figure **4** shows an isometric view of a roller lifter and a two-sided yoke-like constraining mechanism with the location of the flat surfaces on the roller lifter located essentially perpendicular to their position in **FIG. 2**, where the direction of movement of the constraining mechanism is also substantially perpendicular to that shown in **FIG. 2**. Referring now to **FIG. 4**,

this embodiment of the invention shows that the direction of motion of the constraining mechanism **13**, shown by arrow **25**, is substantially perpendicular to the movement of the roller lifter **10**, shown by arrow **26**. Surfaces **12** on the roller lifter may be located at any orientation between those shown in **FIG. 2** and **FIG. 4** as long as interior members **13b** that mate to flat surfaces **12** are substantially parallel to each other. As stated above, the directions of movement indicated by arrows **25** and **26** need not be substantially perpendicular to each other. As in **FIG. 2**, for simplicity one stationary block **14** is also omitted from this view. Only one stationary block **14** is necessary to provide a minimum amount of constraint for roller lifter **10**.

Figure **5** shows an isometric view of multiple lifters with a common two-sided constraining mechanism of the present invention. Referring now to **FIG. 5**, an isometric view of multiple lifters with a common two-sided constraining mechanism **15** ensuring controlled orientation of roller lifters **10** is shown. As with the change in orientation of the constraining mechanism **13** and parallel flat surfaces **12** in **FIG. 4**, these may be oriented substantially perpendicular to the directions shown without altering the operation of the orientation of the roller lifters **10**. As in **FIG. 2**, only three stationary blocks **14** are shown, although adequate constraint, as discussed above, requires a minimum of one stationary block **14**. End members **15a** are engaged within slots **14a** of stationary blocks **14**, and each pair of interior members **15b** each engage the parallel flat surfaces **12** of a roller lifter **10**. One skilled in the art will recognize that additional pairs of interior members **15b** may be added for each additional roller lifter **10** so aligned in the engine.

Figure **6** shows an isometric view of a single roller lifter with a one-sided yoke-like constraining mechanism of the present invention. Referring now to **FIG. 6**, an isometric view of a single roller lifter **10** with a one-sided constraining mechanism **16** is shown. Spring **17** pushes an interior member **16b** of one-sided constraining mechanism **16** against a flat surface **12** of roller lifter **10** to ensure controlled orientation of roller

lifter **10**, constraining movement of roller lifter **10** in the directions represented by arrows **25** and **26**, which, as stated above, need not be substantially perpendicular to each other. As in **FIG. 2,** for simplicity one stationary block **14** is also omitted from this view. Only one stationary block **14** is necessary to provide a minimum amount of constraint for roller lifter **10**. End members **16a** are engaged within slots **14a** of stationary blocks **14**. One skilled in the art will recognize that additional roller lifters **10** could be added along with additional interior members **16b** similar to that shown in **FIG. 5**.

Figure **7** shows an isometric view of a single roller lifter with locating pins and a two-sided, slotted yoke-like constraining mechanism of the present invention. Referring now to **FIG. 7**, an isometric view of a single roller lifter **19** with attached or integral locating pins **20** perpendicular to longitudinal axis **27** of single roller lifter **19** is shown. Two-sided, slotted constraining mechanism **18** has interior members **18b**, each having a slot **18c** which engage each locating pin **20**. As single roller lifter **19** is moved through its arc, locating pins **20** slide in and out of slot **18c** of interior members **18b** of slotted constraining mechanism **18**, in a direction indicated by arrow **26**, while the end members **18a** of slotted constraining mechanism **18** slide fore-and-aft in slots **14a** of stationary blocks **14**, substantially perpendicular to the direction of movement of single roller lifter **19** relative to slotted constraining mechanism **18**, indicated by arrow **25**. These two constraints maintain controlled orientation of single roller lifter **19** as it moves through its arcuate path.

Figure **8** shows an isometric view of a single roller lifter with grooves in the roller lifter for orientation and a yoke-like constraining mechanism with engaging pins of the present invention. Referring now to **FIG. 8**, an isometric view of a single roller lifter **21**, with grooves **22** machined along its length parallel to its longitudinal axis **27** is shown. Engaging pins **23** attached or integral to interior members **24b** of constraining mechanism **24** maintain controlled orientation of single roller lifter **21** as it moves through its arc. Single

roller lifter **21** slides back and forth against engaging pins **23** on interior members **24b** of constraining mechanism **24** in a direction indicated by arrow **26**, while the end members **24a** of constraining mechanism **24** slide fore-and-aft in slots **14a** of stationary blocks **14**, substantially perpendicular to the direction of movement of single roller lifter **21** relative to engaging pins **23** on constraining mechanism **24**, indicated by arrow **25**. These two constraints maintain controlled orientation of single roller lifter **21** as it moves through its arcuate path.

Figure **9** shows an isometric view of a single roller lifter with a one-sided spring-like deformable constraining mechanism of the present invention. Referring now to **FIG. 9**, an isometric view of a single roller lifter **10** and roller **11** with a one-sided constraining mechanism **30** is shown. Base **28** is attached to the internal combustion engine. Deformable member **29** is attached to base **28** at one end, and the other end engages and pushes against a flat surface **12** of roller lifter **10** to ensure controlled orientation of roller lifter **10**, constraining movement of roller lifter **10** in the directions represented by arrows **25** and **26**. Roller lifter **10** is constrained to move in a direction coincident with the deflection of deformable member **29** (arrow **25**), and in a direction substantially perpendicular thereto (arrow **26**), sliding along the end of deformable member **29** in contact with flat surface **12**. As stated above, the directions of movement indicated by arrows **25** and **26** need not be substantially perpendicular to each other.

Roller lifter **10** also moves axially up-and-down along its longitudinal axis **27** as it engages with the cam (not shown), but is prevented from rotating about longitudinal axis **27** due to the limitations on movement provided by constraining mechanism **30**. One skilled in the art will recognize that additional roller lifters **10** could be added along with additional constraining mechanisms **30** similar to that shown in **FIG. 5**.

Having described the present invention, it will be understood by those skilled in the art that many changes in construction and widely differing embodiments and applications

of the invention will suggest themselves without departing from the scope of the present invention.